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June 20, 2007

SAMPLING AND ANALYSIS PLAN FOR ACTIVITY-BASED INDOOR AIR EXPOSURES OPERABLE UNIT 4 LIBBY, MONTANA, SUPERFUND SITE

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APPROVAL PAGE

This sampling and analysis plan for activity-based indoor air exposures for Operable Unit 4 of the Libby, Montana, Superfund Site has been prepared by the U.S. Environmental Protection Agency, Region 8, with technical support from Syracuse Research Corporation and CDM, Inc. Study activities addressed in this Plan are approved.

_____ _____

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DOCUMENT REVISION LOG

Revision	Date	Primary Changes
0	06/20/2007	--

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ABS	Activity-based sampling
CAR	Corrective action request
CIC	Community involvement coordinator
COC	Chain of custody
CSS	Contaminant screening survey
DQOs	Data quality objectives
ED	Exposure duration
EDD	Electronic data deliverable
EF	Exposure frequency
EPA	Environmental Protection Agency
ET	Exposure time
f/cc	fibers per cubic centimeter
FSDS	Field sample data sheet
FSP	Field sampling plan
GO	Grid opening
GPS	Global Positioning System
GSD	Geometric standard deviation
HASP	Health and safety plan
HQ	Hazard Quotient
IDW	Investigation derived waste
ISO	International Organization for Standardization
LA	Libby amphibole
MCE	Mixed-cellulose ester
MET	Meteorological
ND	Non-detect
OU	Operable unit
NOAA	National Oceanic Atmospheric Administration
NSUA	Non-specific use area
NVLAP	National Voluntary Laboratory Accreditation Program
PCM	Phase-contrast microscopy
PCME	Phase-contrast microscopy equivalent
PDI	Pre-design inspection
PLM	Polarized light microscopy
PLN	Poisson lognormal
PM	Project manager
PPE	Personal protective equipment
QA	Quality assurance

QAPP	Quality assurance project plan
QC	Quality control
RBC	Risk-based concentration
RBF	Risk-based fraction
RfC	Reference concentration
RPM	Regional project manager
s/cc	Structures per cubic centimeter
s/cm^2	Structures per square centimeter
SAP	Sampling and analysis plan
SOP	Standard operating procedure
SQAPP	Supplemental quality assurance project plan
SUA	Specific use area
SWQAPP	Site-wide quality assurance project plan
TEM	Transmission electron microscopy
TWF	Time weighting factor
UCL	Upper Confidence Limit
UR	Unit risk
VCS	Vermiculite-containing soil
VI	Vermiculite insulation

SAMPLING AND ANALYSIS PLAN FOR ACTIVITY-BASED INDOOR AIR EXPOSURES OPERABLE UNIT 4 LIBBY, MONTANA, SUPERFUND SITE

1.0 INTRODUCTION

This document is the sampling and analysis plan (SAP) for the collection and analysis of samples of indoor air and potential sources of indoor air contamination at residential and commercial buildings located within Operable Unit (OU) 4 of the Libby, Montana, Superfund Site. OU4 includes most current homes and businesses in the community of Libby.

This SAP contains the elements required for both a field sampling plan (FSP) and quality assurance project plan (QAPP). This SAP has been developed in accordance with the Environmental Protection Agency (EPA) Requirements for Quality Assurance Project Plans (EPA 2001) and the Guidance on Systematic Planning Using the Data Quality Objectives Process – EPA QA/G4 (EPA 2006). The SAP is organized as follows:

Section 1 – Introduction
Section 2 – Background and Problem Definition
Section 3 – Data Quality Objectives
Section 4 – Sampling Program
Section 5 – Laboratory Analysis and Requirements
Section 6 – Assessment and Oversight
Section 7 – Data Validation and Usability
Section 8 – Project Schedule
Section 9 – References

2.0 BACKGROUND AND PROBLEM DEFINITION

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from this mine contains varying levels of a form of asbestos referred to as Libby Amphibole (LA). Historic mining, milling, and processing operations at the site are known to have caused releases of vermiculite and LA to the environment that have caused a range of adverse health effects in exposed people, including not only workers at the mine and processing facilities (Amandus and Wheeler 1987, McDonald et al. 1986, McDonald et al. 2004), but also in residents of Libby (Peipins et al. 2003).

Starting in 2000, EPA began taking a range of cleanup actions at the site to reduce or eliminate sources of LA exposure to residents and workers. In the early stages, efforts were focused mainly on wastes remaining at former vermiculite processing areas (the screening plant, export plant, etc.). As work progressed, attention soon shifted to cleanup of current homes and workplaces in OU4. The protocol that EPA developed for investigating sources of LA at specific properties and deciding when to take action is detailed in a Technical Memorandum issued in December 2003 (EPA 2003a). Cleanup actions taken under this protocol typically include removal of unenclosed vermiculite insulation (VI) from living spaces and other readily accessible spaces (e.g., unfinished attics), removal of some or all contaminated outdoor soils, and may, in some cases, include cleanup of indoor dusts.

2.1 Problem Definition

One issue of high priority to EPA is an evaluation of the efficacy and protectiveness of the current cleanup strategy. That is, answers are needed for the following questions:

- At a property that EPA has investigated and found no reason to take any cleanup actions under the approach described in EPA (2003a), are the risks that remain sufficiently small to be considered acceptable?
- At a property where EPA has investigated and determined that one or more sources was present that required cleanup under the approach described in EPA (2003a), are the risks that remain after the cleanup is complete sufficiently small to be considered acceptable?

Note: For convenience, in this document, the phrase "**post-cleanup property**" will be used to indicate any property where EPA has investigated sources and has either taken cleanup action or else determined that no cleanup action is needed under the current decision-making protocol.

Residual exposures that may remain at post-cleanup properties may be divided into two main types:

- Exposures that occur inside the building
- Exposures that occur outside the building

This SAP is focused on collection of data needed to support an evaluation of the residual level of exposure and risk that may exist inside post-cleanup properties. Collection of data needed to evaluate residual exposures and risks from exposures that occur outside the building at post-cleanup properties is addressed in a separate sampling plan (EPA 2007).

2.2 Conceptual Model for Post-Cleanup Indoor Exposures

Cleanup actions at a property are intended to address both indoor or outdoor sources that exceed the trigger levels specified in the Technical Memorandum (EPA 2003a). However, the cleanup strategy may leave some residual sources and exposure pathways in place. The residual sources that may impact indoor air at post-cleanup properties are discussed below.

2.2.1 Outdoor Air

All buildings exchange indoor air for outdoor air (ventilation). In warm weather, this may occur through open windows or doors. In cold weather, heating of indoor air creates a negative pressure inside the building, and this tends to draw outdoor air in through leaks and cracks in the building. Thus, in the absence of other sources, levels of LA in indoor air in a post-cleanup building are expected to be generally similar to the levels in outdoor ambient air in that area.

2.2.2 Releases from Residual Indoor Sources

As noted above, if a building is found to contain unenclosed VI in an accessible area, that unenclosed VI is removed as part of the EPA cleanup action. Moreover, if any observable leakage of VI into indoor living space is observed, this area is also cleaned up. Finally, if indoor dust is found to contain more than 5,000 LA structures per square centimeter (s/cm^2), the indoor dust is also cleaned up. Thus, under post-cleanup conditions, the residual indoor sources of LA contamination in indoor dust and indoor air may include: 1) trace levels of VI or LA from areas that have been cleaned, 2) residual VI or LA in areas that have not been cleaned, including floor, carpets, upholstery, air ducts, etc., and 3) VI that is presently contained in an intact structure (e.g., a wall).

2.2.3 Transport from Contaminated Areas of Yard Soil

Under the current cleanup protocol (EPA 2003a), outdoor soils are divided into "specific use areas" (SUAs) that include areas such as gardens and play areas where human exposure is likely to occur on a frequent basis, and "non-specific use areas" (NSUAs) that include general areas of the yard where human exposure is likely to occur less frequently. Under the current approach (EPA 2003a), the triggers for cleanup (removal and replacement with clean fill) of outdoor soil are summarized below:

Mandatory Triggers (these conditions always trigger a soil clean-up in the location exceeding the trigger)

- Any level of visible vermiculite in a SUA
- Gross levels of visible vermiculite (approximately 50% by volume or higher) in a NSUA
- Any location where analysis by polarized light microscopy-visual area estimation (PLM-VE) is equal to or greater than 1%

Conditional Trigger (this condition does not trigger a clean-up of the area unless some other trigger for cleanup has been exceeded at the property)

- Any area where PLM-VE is > ND but < 1% (ND = not detected)

Thus, the types and levels of LA and vermiculite that may remain in outdoor soil at a post-cleanup property are summarized below:

Case	Potential Residual Sources in Outdoor Soil
1. No cleanup triggers were exceeded either indoors or outdoors; no action taken	- non-gross visible vermiculite in any NSUA - PLM-VE < 1% in any area
2. One or more triggers were exceeded (either indoors and/or outdoors); cleanup action taken	- non-gross visible vermiculite in a NSUA (PLM-VE = ND)

These residual sources in outdoor soil may serve as a continuing source of LA into indoor spaces by transport of contaminated soil on shoes, clothing, etc.

2.2.4 Transport from Other Sources

In the past, transport of LA into homes may have occurred on the clothing of workers at the mine or processing areas. Likewise, transport may have occurred from readily accessible piles of waste vermiculite that were present at various locations around the community. Although the mine has ceased operation and EPA has removed contamination from a number of the most heavily contaminated publicly accessible source areas, some smaller or less contaminated source areas may still remain, and these could serve as a continuing source for contamination of indoor dust and indoor air.

2.3 Overview of Existing Data

EPA has collected some initial data on the levels of LA that occur in indoor air at pre- and post-cleanup properties (EPA 2005). The available data[1] for pre-cleanup properties are shown in Figure 2-1. In brief, personal air samples were collected from people who were engaged in either "routine" indoor activities, or who were engaged in "active cleaning" (dusting and sweeping). Stationary air samples and indoor dust samples were also collected at each sampling location. As seen in Figure 2-1, a wide range of LA levels were observed in both personal and stationary indoor air, with little apparent dependence on the measured level of LA in dust collected from indoor surfaces. This result is somewhat unexpected, because it is generally assumed that LA in indoor dust is likely to be a significant source of LA in indoor air.

The available indoor air data[1] from four post-cleanup properties are summarized in Figure 2-2. In brief, indoor air stationary monitors were used to collect indoor air samples at varying time periods following completion of all cleanup actions at the property. As seen, levels were generally low following cleanup, and remained low for about a year. However, at some of the homes, there appears to be an upward trend, suggesting the potential for re-contamination. EPA is presently evaluating these data and selecting follow-up activities to further clarify the reason for the apparent increases.

While informative, these initial data are not sufficient to support reliable risk assessment or risk management decisions regarding exposure or risks from indoor air because of the following data limitations:

- Not enough samples have been collected to adequately limit statistical uncertainty
- Not enough samples have been collected to ensure adequate spatial and temporal (seasonal) representativeness of the data

[1] Note: the data shown in Figures 2-1 and 2-2 are not yet fully validated and some values may be revised as needed.

- Not enough data have been collected to establish a quantitative relation between LA levels in indoor dust and LA levels in indoor air.

Thus, the primary problem that this SAP seeks to address is the lack of sufficient data on indoor air levels to support decisions about residual exposure and risks from LA in indoor air at post-cleanup properties in Libby.

3.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are statements that define the type, quality, quantity, purpose, and use of data to be collected. The design of a study is closely tied to the DQOs, which serve as the basis for important decisions regarding key design features such as the number and location of samples to be collected and the chemical analyses to be performed. In brief, the DQO process typically follows a seven-step procedure, as follows:

1. State the problem that the study is designed to address
2. Identify the decisions to be made with the data obtained
3. Identify the types of data inputs needed to make the decision
4. Define the bounds (in space and time) of the study
5. Define the decision rule which will be used to make decisions
6. Define the acceptable limits on decision errors
7. Optimize the design using information identified in Steps 1-6

Following these seven steps helps ensure that the project plan is carefully thought out and that the data collected will provide sufficient information to support the key decisions which must be made. The following paragraphs implement the DQO process for this project.

3.1 State the Problem

EPA has been working to clean up both indoor and outdoor sources of VI, vermiculite-containing soil (VCS) and LA at properties in OU4. However, under the current cleanup strategy (EPA 2003a), some residual level of LA may remain at post-cleanup properties, both indoors and outdoors. Therefore, in order to determine if the current cleanup strategy is both effective and protective, the primary goal of this effort is as follows:

Primary Objective (Evaluate Efficacy and Protectiveness)

Collect data needed to characterize the level of residual exposure and risk from indoor exposures that may remain at post-cleanup properties. If some properties have residual risk above a level of concern, identify the most likely residual source(s) contributing to the contamination so that the cleanup strategy may be revised to increase protectiveness.

While evaluation of risks from indoor air at any specific post-cleanup property may be assessed by direct assessment of indoor air samples from that property, it is desirable, if possible, to develop a method for predicting the level of risk from indoor air based on measurements of the level and extent of known residual sources. If such a method can be developed and shown to yield reliable predictions, then this method may be used to compute risk-based concentrations

(RBCs) of LA in various source materials, and this information can be used to help guide cleanup actions at the site. Based on this, the secondary objective of this effort is:

Secondary Objective (Develop Exposure Model)

Collect sufficient data on the level of LA in indoor air and in potential source media (e.g., indoor dust, outdoor soil, ambient air) that a quantitative model may be developed to predict indoor air levels from data on source levels with sufficient accuracy to support cleanup and risk management decisions.

3.2 Identify the Decisions

The data to be collected during this effort are intended to support the following decisions:

1) Are current strategies for cleaning up properties in OU4 adequate to provide health protection from exposures in indoor air?

> Note: In making this decision, it is important to emphasize that the basis for assessing the level of cancer risk from asbestos is currently undergoing Agency review, and the approach may be revised in the future as new methods are developed and as new toxicity data on asbestos are obtained. In addition, EPA has not yet developed a method for assessing non-cancer risks from inhalation exposure to asbestos. Thus, all evaluations of protectiveness that are based on currently available risk assessment methods should be viewed as interim, and these interim decisions may be revised in the future as methods and data for assessing the cancer and non-cancer risks of asbestos are improved.

2) If indoor air levels are above a level of concern in some post-cleanup buildings, what are the residual indoor or outdoor sources most likely to be responsible?

3) Do the data indicate a quantifiable relationship between the level and extent of LA in residual sources and the level observed in indoor air? If so, can long-term average exposure levels be predicted with sufficient accuracy to be useful in risk assessment and risk management decision-making?

3.3 Identify the Types of Data Needed

The data needed to achieve the primary objective of this effort consist of measures of LA in indoor air at a wide variety of post-cleanup properties. In order to achieve the secondary

objective, data are also required on the types and levels of residual sources that may remain at each location. The following sections identify key attributes of the data needed for this effort.

3.3.1 Sampling Locations

Based on the current protocol for cleanup actions at a property, post-cleanup locations may be stratified into the following categories based on whether or not outdoor soil cleanup actions were taken, and on what remains in outdoor soil post-cleanup:

Category	Did Outdoor Soil Cleanup Take Place?	Post-cleanup Surface Soil		
		VCS		PLM Detect
1	No	-	and	-
2		+	or	+
3	Yes	-	and	-
4		+	and	-

VCS = Vermiculite-containing soil
PLM = Polarized light microscopy

In order to ensure that the set of post-cleanup properties selected for assessment in this effort are representative, the data set collected during this effort should include a number of properties from each category. This stratification will also help increase the ability to identify potential residual sources of concern if post-cleanup levels are found to exceed a level of health concern.

Note that, as part of the data collection effort for this project, additional data (both visual and analytical) will be collected to better characterize the level and extent residual LA contamination in outdoor soil at post-cleanup properties (see Section 3.3.3, below). These additional data will be used in the analysis of the data to search for relationships between indoor air and outdoor soil, and may, if available in a timely fashion, help guide the selection of properties for testing to ensure a representative set of properties are evaluated.

Comment [R1]: OK.

3.3.2 Types of Indoor Air Samples

There are a variety of different options for collecting samples of indoor air. Important variables include:

- Type of sampling device (personal *vs.* stationary monitor)
- Type of activity occurring during sampling

Indoor air samples may also be collected under a variety of differing activity scenarios, with varying levels of activity and source disturbance. While there are a wide variety of such activities, it is not necessary to collect data under every possible combination of activity and source disturbance. Rather, for the purposes of this effort, samples should be representative of two generic conditions:

- Active behaviors
  This category includes a wide range of indoor activities in which a person is moving about the building and potentially disturbing indoor sources. For example, walking from room to room, sitting down on upholstered chairs, dusting, sweeping, vacuuming, and moving furniture would all be included.
- Passive behaviors
  This category includes activities such as sitting and reading a book, watching television, and working at a desk. The key attribute is that the person is engaging in minimally energetic actions that will have low tendency to disturb source materials.

Section 4.3 (below) provides a more detailed description of the specific activities that will be included in each activity category during sample collection.

3.3.3 Data on Residual Source Levels

As noted above, the secondary objective of this effort is to obtain data on the relationship between LA levels in indoor air and in various potential residual sources, including ambient air, outdoor soil, and indoor dust.

Outdoor Ambient Air

Data on LA levels in ambient air are presently being collected on an on-going basis at 14 stations in OU4. Thus, no additional ambient air sampling is needed. The data from the ambient air program will be utilized to help evaluate the contribution of outdoor air to indoor air.

Outdoor Soil Samples

Data on LA levels in pre-cleanup outdoor soil are available as part of the Contaminant Screening Survey (CSS) and (in some cases) the Pre-Design Inspection (PDI) performed at each cleanup property. While the post-cleanup pattern of residual VCS and LA in yard soil can be deduced from the property specific CSS, PDI, and removal design, a substantial level of effort is needed to estimate area-weighted average post-cleanup soil levels from this report. Therefore, supplemental data on the level and extent of residual soil contamination will be collected at all properties evaluated as part of this effort. This supplemental data will consist of four parts:

- Surficial soils will be inspected at a maximum density of 1 point per 100 ft^2 and a semi-quantitatve estimation of vermiculite quantity will be assigned to each point inspection.
- A sketch of the yard that shows the location and size of any areas with visible vermiculite, along with an indication of the relative amount as described in CDM-SOP Libby-06, Revision 1
- One 30-point composite soil sample than combines soils from all NSUAs, to be analyzed by PLM-VE
- One 30-point composite sample that combines soils from all SUAs, to be analyzed by PLM-VE

These data will provide a sufficient characterization of residual outdoor soil levels at various categories of post-cleanup properties, and will support an assessment of whether residual VCS or LA in outdoor soil may pose a continuing source to indoor dust or air.

Indoor Dust

Data on pre-cleanup indoor dust levels are collected at each cleanup property as part of the CSS or PDI, but post-cleanup dust samples are generally not collected, even when an indoor dust cleanup occurs. Therefore, in order to support the secondary objective of this sampling effort, indoor dust samples will be collected at all post-cleanup properties selected for inclusion. Dust samples will be collected from floors and other horizontal surfaces that may be disturbed by routine indoor activities. Dust samples will be collected using a microvacuum technique, collecting a 30-point composite from each post-cleanup property, as described in [Cite revised SAP for dust here]

Comment [R2]: I assume this has been revised to be consistent with approach being used in Troy.

Other Indoor Sources

As noted above, other residual sources that may contribute to LA in indoor air in post-cleanup properties includes things such as carpets, upholstery, air ducts, and VI in enclosed spaces. While there are too many independent variables to allow measurement and stratification of sampling locations based on all of these potential residual sources, it is important that the data collected at each property include a thorough documentation of all potential sources known to exist in the building. Information collected regarding residual sources will be captured on an ABS investigation form included in Attachment A. If a subset of properties is recognized as having higher indoor air levels of LA than most others, these data on residual sources may help form hypotheses about which residual sources are most likely to be responsible, which in turn may form the basis for a focused follow-up investigation, as may be judged necessary to support decision-making. If information collected on the ABS investigation form is inconsistent with data collected during previous investigations, the current override system of updating property information in the project database (Libby2) will be used.

3.4 Define the Bounds of the Study

3.4.1 Spatial Bounds

The spatial bounds of this study are restricted to properties located within OU4 of the Libby Superfund site. This OU includes most current residential and commercial properties in the community. Note, however, that the results of this study may also be useful in assessing cleanup efficacy under similar conditions in other operable units at the site.

3.4.2 Temporal Bounds

Human health risk from exposure to LA in indoor air is related to the long-term average concentration in indoor air. Because the level of LA in indoor air may depend on factors that vary seasonally (e.g., indoor activity patterns, humidity, building ventilation rate), the data set needed for this effort should consist of multiple samples from each residence, spanning a range of time points and meteorological conditions. This will help ensure that reliable estimates of long-term average concentration may be computed from the individual short-term measurements.

3.5 Define the Decision Rule

3.5.1 Primary Decision Rule

For the primary objective of this effort (evaluation of cleanup efficacy), the decision rule is:

> If the level of risk to humans from exposure to indoor air at a post-cleanup location, when combined with the level of risk which applies to the same individuals from other applicable exposure pathways, does not exceed a cancer risk of 1E-04 or a non-cancer Hazard Quotient (HQ) of 1.0, then risks at that property will be considered acceptable. If the total risk exceeds a cancer risk of 1E-04 or an HQ of 1.0, then the feasibility of further reducing exposure from either the indoor air pathway and/or the other applicable exposure pathways shall be assessed.

At present, EPA has not developed a quantitative procedure for evaluating non-cancer risks, but has developed a method for quantification of cancer risk (IRIS 2007). The basic equation is:

$$Risk(i) = C(i) \cdot TWF(i) \cdot UR(i)$$

were:

Risk(i) = Risk of dying from a cancer that results as a consequence of exposure from specified exposure scenario "i"

C(i) = Average concentration of asbestos fibers in air (f/cc) during exposure scenario "i"

UR(i) = Unit Risk $(f/cc)^{-1}$ that is appropriate for exposure scenario "i"

TWF(i)= Time weighting factor for exposure scenario "i". This factor accounts for less-than-continuous exposure during the exposure interval.

Because each person can be exposed from more than one source, the total cancer risk is calculated by summing the risks from each exposure pathway that applies:

$$\text{Total risk} = \Sigma \text{ Risk(i)}$$

As noted above, this document is focused on collection of data on the concentration of asbestos that people breath in indoor air in Libby. These data will be used to evaluate the risk from the indoor air exposure scenario. This risk estimate will, in turn, be combined with risk estimates for other pathways to estimate total exposure.

Because of limitations in the current methods for assessing risks from asbestos, all decisions regarding residual risk levels are considered interim, and interim decisions may be revisited in the future as new methods and new data become available.

3.5.2 Secondary Decision Rule

For the secondary objective of this effort (development of a quantitative indoor air exposure model based on measures of LA in residual sources), the decision rule is:

> If the available data establish a clear relationship between long-term average indoor air levels and levels of LA in one or more residual sources, it will be concluded that development of a quantitative exposure model is appropriate and this may be used to estimate exposure from indoor air at locations where no indoor air data have been collected. Conversely, if no apparent relationship between long-term indoor air levels and residual sources can be established, it will be concluded that predictive approaches are not feasible at this site, and that other strategies for evaluation of exposure from indoor air are needed.

3.6 Define the Acceptable Limits on Decision Errors

3.6.1 Primary Decision Rule

In making decisions about the long-term average concentration of LA in indoor air and the level of health risk associated with that exposure, two types of decision errors are possible:

- A false negative decision error would occur if a risk manager decides that exposure to indoor air is not of significant health concern, when in fact it is of concern.
- A false positive decision error would occur if a risk manager decides that exposure to indoor air is above a level of concern, when in fact it is not.

EPA is most concerned about guarding against the occurrence of false negative decision errors, since an error of this type may leave humans exposed to unacceptable levels of LA in indoor air. For this reason, it is anticipated that decisions regarding this pathway will be based not only on the best estimate of the long term average concentration, but will also consider the 95% upper confidence limit (UCL) of the long-term average concentration. Use of the UCL to estimate exposure and risk helps account for limitations in the data, and provides a margin of safety in the risk calculations, ensuring that risk estimates are unlikely to be too low.

EPA is also concerned with the probability of making false positive decision errors. Although this type of decision error does not result in unacceptable human exposure, it may result in unnecessary expenditure of resources. For the purposes of this effort, the strategy adopted for controlling false positive decision errors is to seek to ensure that, if the exposure estimate based on the 95% UCL is above EPA's level of concern for this pathway, then the UCL is not larger than 3-times the best estimate of the mean. If the 95% UCL is at or above the range that is of potential concern, and the UCL is greater than 3 times the best estimate of the mean, then it will be concluded that there is a substantial probability of a false positive error and that more data may be needed to strengthen decision-making.

3.6.2 Secondary Decision Rule

In determining whether the data are adequate to support development of a quantitative exposure model for indoor air, the key issue is how accurately the model can predict the observed long-term average indoor air concentration as a function of the data available on the concentration of asbestos in potential sources. The general form of the model would be as follows:

$$C(\text{Indoor air}) = k1 \cdot C(\text{Outdoor air}) + k2 \cdot C(\text{Indoor dust}) + k3 \cdot C(\text{Outdoor soil}) + k4 \cdot C(\text{Other sources})$$

where k1, k2, k3 and k4 are empiric "transfer factors" to be derived from the data that characterize the relative contributions of each source to indoor air.

Although final evaluations can not be made until a model is developed and assessed, if predicted concentration in indoor air are found to be within 2-fold of observed long-term average values at 80% or more of evaluated properties, the model will be considered to be appropriate for use in quantitative risk assessment and in supporting risk management decision making. If the predictive accuracy of the model does not achieve this level, then the model may be used semi-quantitatively, coupled with an appropriate identification and discussion of the attendant uncertainty in the calculations.

3.7 Optimize the Design

3.7.1 Limiting the Uncertainty in Estimates of Long-Term Average Concentration

The method used to compute the UCL of a set of indoor air samples depends on the statistical properties of the data set. At present, data on the distributional form and between-sample variability are limited. Figure 3-1 shows log-probability plots of available personal indoor air samples stratified by activity level (active *vs.* routine). As seen, the data are moderately well-characterized by a lognormal distribution, and the value of sigma appears to be in the range of about 2 (geometric standard deviation [GSD] = 7-8). Note that these data are not stratified by level of LA in source materials, so actual values of sigma may be somewhat lower.

If it is assumed that the variability between different samples is likely to be approximately lognormal, then the data set collected from a location or a set of similar locations may be approximated by a mixed Poisson lognormal (PLN) distribution. Statistical procedures are available to estimate the parameters of the underlying lognormal distribution (Haas et al. 1999), and these fitted parameters may be used to compute the UCL of the mean using the approach for lognormal data sets described in EPA 1992. Based on this approach, the ratio of the UCL to the mean of a data set (an indication of the statistical uncertainty in the data) is given by:

$$\frac{UCL}{Mean} = \exp\left(\sigma H / \sqrt{(n-1)}\right)$$

where:

σ = log standard deviation of the measured values
H = statistic described in EPA 1992
n = number of samples

Figure 3-2 illustrates the ratio of the UCL to the mean as a function of n for an assumed value of σ of 2.0. As seen, the ratio (a measure of uncertainty) approaches a value of about 2 as the

number of samples approaches about 80-100, and continues to decline slowly as the number of samples increases. Based on this analysis, it is expected that if a total of about 80-100 samples per property type were collected, the uncertainty in the average concentration would be limited to less than a factor of 3, and that collection of additional samples would result in minimal decreases in uncertainty. Because four samples will be collected per property (on a quarterly basis), if there were 20 properties in each of the four categories, this would result in a total of 80 measurements, which should result in an acceptable limit on the width of the uncertainty bounds around the long-term average value.

3.7.2 Estimating the Required Analytical Sensitivity for Indoor Air

For the purposes of this effort, the analytical sensitivity that is needed for analysis of indoor air samples should be sufficient to ensure reliable detection and quantification if risks from activity-based sampling (ABS) air approach or exceed a level of health concern. The choice of the level of concern is complicated by the fact that residents and workers in Libby may be exposed to asbestos by more than one pathway, and hence risk management decisions must consider the total (cumulative) risk from all pathways combined. With this in mind, the target level of concern for the indoor air pathway alone is set at a cancer risk of 1E-05 (1 in 100,000) or a non-cancer HQ of 0.1. That is, the target sensitivity is selected such that, if the true concentration of LA in indoor air corresponds to a risk that could contribute risk 1/10 the total level of concern (1E-04), the concentrations in air would be readily detectable and quantifiable with good confidence. If the true concentration corresponds to a risk that is less than 1/10 the total level of concern, exact quantification of the pathway becomes less important. The concentration of LA in indoor air that is associated with a risk level of 1E-05 is derived from the basic risk equations described above, simply by solving for the concentration that yields a risk of 1E-05:

$$1E\text{-}05 = C(air) \cdot TWF\ D\ UR$$
$$C(air) = 1E\text{-}05 / (TWF \cdot UR)$$

Note that the type of fibers included in this concentration is defined by the risk model. For example, the current EPA approach is based on phase contrast microscopy (PCM) fibers, which are defined as asbestos fibers longer than 5 um, thicker than 0.25 um, and with an aspect ratio greater than 3:1. For convenience, the fibers used in a risk model are called “risk-based fibers”.

In most cases, the risk-based fibers are only a sub-set of the total asbestos fibers present in air. The fraction of fibers that are risk-based is referred to as the “risk-based fraction” (RBF):

$$RBF = C(risk\text{-}based) / C(total)$$

At the Libby site, current analytical methods focus on measuring the concentration of total fibers, and sufficient data have accumulated to estimate the RBF with good accuracy. Thus, the concentration of PCM fibers may be calculated from a measure of total fibers as follows:

$$C(\text{risk=based}) = C(\text{total}) \cdot \text{RBF}$$

This approach provides an estimate of the concentration of risk-based fibers that has lower statistical uncertainty than if only risk-based fibers were measured, and may be applied to any risk model that may be of interest.

Based on this approach, the concentration of concern of total asbestos associated with a specified risk level (1E-05) is calculated as follows:

$$\text{Concentration of Concern (Total TEM s/cc)} = (1E\text{-}05) / (\text{RBF} \cdot \text{TWF} \cdot \text{UR})$$

For planning purposes, it is conservatively assumed that the TWF for exposure to indoor air is 1.0. This value corresponds to continuous exposure (24 hours per day, 365 days per year) for a lifetime. It is considered likely that most residents will have indoor air exposures in Libby that are less than this assumption.

Based on EPA's currently recommended cancer risk model (IRIS 2007), the unit risk factor for lifetime exposure is 0.23 per phase-contrast microscopy (equivalent) (PCM(E)) fibers per cubic centimeter (f/cc). Based on particle size data from the Libby Site, the fraction of total LA fibers in air that are PCME fibers is about 0.45. Thus, the concentration of concern for total LA in outdoor ABS air would be about:

$$\text{Concentration of cancer concern (1E-05 risk level)} = (1E\text{-}05) / (1.0 \cdot 0.45 \cdot 0.23) = 0.0001 \text{ s/cc}$$

As noted above, the EPA has not yet developed a method for evaluating non-cancer risks from asbestos, so it is not yet possible to compute an analogous level of concern for non-cancer effects. In the absence of data, it is tentatively assumed that the target analytical sensitivity that is adequate for evaluating cancer risk will also be sufficient for evaluating non-cancer risks. EPA toxicologists are currently working to develop an RfC for asbestos based on available data on LA and other forms of asbestos, and this assumption will be re-visited when an RfC is approved for use.

Ideally, it would be desirable to select a target sensitivity somewhat lower than 0.0001 cc^{-1} in order to account for potential future revisions in the risk assessment approach for asbestos as

new data are obtained and as new models are developed. However, because the personal air samples collected during this effort will be characterized by relatively low air volumes (10 L/min · 60 min/hr · 4 hrs = 2400 L), the number of grid openings (GOs) that require analysis in order to achieve a lower target analytical sensitivity (e.g., 0.00004 cc^{-1}) is rather large (about 400 GOs per sample). Recognizing that the total number of air samples to be analyzed as part of this program is large (20 properties per soil category x 4 soil categories x 4 samples per property x 2 activity types per sampling event = 640), the number of GOs needed for this number of samples (a total of more than 250,000) is considered to be impractical. Indeed, even a target sensitivity of 0.0001 cc^{-1} requires 160 GOs per sample for a total of over 100,000 GOs, which may still be difficult to achieve.

In the event that this total number of GOs is judged to be impracticable, a Monte Carlo simulation was performed to determine the relative statistical penalty imposed by either a) selecting an increase in target sensitivity, or b) selecting a decrease in total number of samples collected per category. Three cases were considered:

Case	Number of samples per category	Target Sensitivity $(cc)^{-1}$	GOs Required per Sample	Total GOs Required
1	100	0.0001	160	103,000
2	50	0.0001	160	51,000
3	100	0.0002	80	51,000

All cases assume that the set of samples collected over time from each of the properties in a soil category may be combined into a single data set for the purposes of estimating the average concentration and the 95% UCL of the mean. The calculations also assume that between-sample variability is relatively large (GSD = 8), and that the average indoor air concentration is about 0.0002 total LA s/cc (the target analytical sensitivity).

Figure 3-3 plots the distributions of the ratio of the 95% UCL of the mean (calculated by fitting each Monte Carlo simulated data set to a Poisson lognormal distribution, as described above) divided by the true mean. The ideal distribution of UCL values would have about 5% of the distribution to the left of the vertical line at 1.0 (i.e., the UCL is lower than the true mean 5% of the time), and the distribution of UCL values to the right of the line would be as narrow as possible (to limit the occurrence of false positive errors). As seen, using Case 1 as the frame of reference, the effect of decreasing sample number (Case 2) results in a considerable increase in the width of the distribution of UCL values, while reducing the analytical sensitivity (Case 3) results in only a small increase in the distribution width. These results indicate that data quality

would be substantially impaired by decreasing sample number, but only slightly impaired by increasing analytical sensitivity. For this reason, the target analytical sensitivity is set to 0.0002 cc^{-1}. If the data generated using this sensitivity are subsequently judged to be insufficient, analysis of additional grid openings from each sample may be performed, as needed to gain improved analytical sensitivity.

Estimating the Required Analytical Sensitivity for Indoor Dust

If a quantitative relationship between LA in indoor dust and in indoor air were established, this could be used to calculate a risk-based concentration of LA in indoor dust, and this could be used to select a target analytical sensitivity for dust. While screening level values for dust to air relationships are available from the literature (e.g., see EPA 2003a), studies at Libby have not yet provided any firm basis for identifying a reliable site-specific dust-to-air transfer factor. Thus, in the absence of such a risk-based approach, a target analytical sensitivity of 20 cm^{-2} is selected for dust samples collected during this effort. This value is at the low end of what is considered practical (requiring analysis of about 50-100 grid openings per sample). It is also suspected that dust levels below about 20 s/cm^2 are likely to be of relatively low concern as a source of indoor air contamination.

3.7.3 Refinements to the Design as Data are Collected

In accord with EPA's DQO process, it is expected that the indoor air monitoring program described in this document may be modified periodically as data are obtained. For example, if data suggest that the variability in concentrations over time is low, then EPA may decrease the number of samples collected over a specified period of time. Alternatively, if data suggest that the variability in concentrations is higher than expected, then additional samples may be added to better limit the uncertainty in the values. Similarly, the target analytical sensitivity may be either increased or decreased, depending on the detection frequency, mean values, and sample variability observed in initial samples results, and on the RfC value when it becomes available. Finally, the design may be revised if new methods for evaluating cancer or non-cancer effects are developed and approved for use by EPA.

4.0 SAMPLING PROGRAM

This section provides brief summaries of standard operating procedures (SOPs) and additional site-specific detail that may not be discussed in the SOPs. All activities will be performed in accordance with this SAP. Site-specific sampling procedures will be followed during the indoor ABS investigation. Field personnel will refer to the Site-Wide Quality Assurance Project Plan (SWQAPP) (CDM 2007a) sections listed below for details regarding requirements referenced in this SAP:

SWQAPP Section Number	Section Title
3.1	Sample Collection
3.2.1	Drafting and Approval of Governing Documents
3.2.2	Field Planning Meetings
3.2.3	Field Team Training Requirements
3.2.4	Field Logbooks
3.2.5	Field Sample Data Sheets (FSDSs)
3.2.6	Investigation Specific Field Forms
3.2.7	Photographic Documentation
3.2.8	Global Positioning System (GPS) Point Collection
3.2.9	Field Equipment Maintenance
3.2.10	Handling IDW
3.2.11	Field Sample Custody and Documentation
3.2.12	Sample Packaging and Shipping
3.2.13	Modification Forms
3.2.14.1	Field Surveillances
3.2.14.2	Field Audits

The SOPs and site-specific procedures to be utilized during this sampling event are listed below and included in Attachment A:

- Sample Custody (Modified SOP 1-2)
- Packaging and Shipping of Environmental Samples (Modified SOP 2-1)
- Guide to Handling of Investigation-Derived Waste (Modified SOP 2-2)
- Field Logbook Content and Control (Modified SOP 4-1)

- Photographic Documentation of Field Activities (Modified SOP 4-2)
- Field Equipment Decontamination at Nonradioactive Sites (Modified SOP 4-5)
- Control of Measurement and Test Equipment (SOP 5-1)
- Sampling of Asbestos Fibers in Air (EPA-LIBBY-01) (EPA 2001)
- SAP for Indoor Dust, Revision 0 (EPA 2003b)
- Site-Specific Standard Operating Procedures for Soil Sample Collection (CDM-Libby-05, Revision 2)
- Site-Specific Standard Operating Procedure for Semi-Quantitative Visual Estimation of Vermiculite in Soil (CDM-Libby-06, Revision 1) with modifications

Comment [R3]: Change to Troy SAP?

The following sections are a summary of field activities that will be performed in accordance with this SAP by CDM during the indoor ambient air sampling investigation.

4.1 Pre-Sampling Activities

Prior to beginning field activities, sampling locations will be selected, a field planning meeting will be conducted, and an inventory of supplies will be performed to determine procurement needs. The following sections discuss these pre-sampling activities.

4.1.1 Selection of Sampling Locations

As discussed in Section 3.3, it is important that the locations selected for evaluation be representative of the types and levels of residual sources that may remain at post-cleanup properties. The four main categories of property are:

Category	Did Outdoor Soil Cleanup Take Place?	Post-cleanup Surface Soil		
		VCS		PLM Detect
1	No	-	and	-
2		+	or	+
3	Yes	-	and	-
4		+	and	-

The target number of homes in each category is 20 (80 total).

To the extent possible, the 20 homes in each category should be selected to provide a reasonable spatial representation in OU4. In order to achieve this objective, the list of all post-cleanup

properties in OU4 will first be stratified according to the four categories above, and then into three different sub-areas (north, central, and south), as shown in Figure 4-1. CDM's Community Involvement Coordinator (CIC) will then contact the residents at the properties in each category in each sub-area to determine if they are willing to participate in this investigation. The objective is to obtain participation from 6-7 properties in each category from each area.

As noted above, additional data on the occurrence of LA in outdoor soil at each property will be collected as part of this effort, and these additional data will be utilized in the data analysis phase. If the data are available in a timely fashion, they may also be used to help ensure that the homes selected for study provide a representative set of LA levels in post-cleanup soils.

Comment [R4]: OK.

4.1.2 Community Coordination

Prior to the implementation of the sampling events described in this SAP, the owner of each property where sampling is proposed will be contacted to determine his/her desire to participate in this investigation. The property owner will be advised of the study's duration (at least a year and perhaps longer), sampling frequency, and will be informed of the importance of obtaining samples consistently over that extended time period. Residents will be asked to not engage in cleaning activities for one week prior to the sampling event. Access agreements will be obtained as required.

4.1.3 Field Planning Meeting

A field planning meeting will be conducted in accordance with the procedures detailed in Section 3.2.2 of the SWQAPP (CDM 2007a).

4.1.4 Training Requirements

Training requirements described in Section 3.2.3 of the SWQAPP (CDM 2007a) will apply to personnel conducting sample collection activities described in this SAP.

4.1.5 Inventory and Procurement of Equipment and Supplies

The following equipment will be required for sampling activities, and any required equipment not already contained in the field equipment supply inventory will be procured prior to initiation of sampling activities:

- Field logbooks
- Indelible ink pens
- Digital camera

- Air sample media: 0.8 um pore, 25 mm diameter mixed cellulose ester (MCE) filter cassettes
- Dust sample media: 0.45 um pore, 25 mm diameter MCE filter cassettes
- Sample paperwork and sample tags/labels
- Custody seals
- Zipper-top baggies
- Personal air sampling equipment
- PPE as required by the site Health and Safety Plan (HASP)

4.2 Sample Collection

4.2.1 Indoor Air Sampling

As discussed above, this effort is focused on collection of personal air samples rather than stationary air samples. Because wearing personal air samplers is not convenient, rather than requesting residents to submit to this approach, EPA will use contractor staff to wear the personal air monitors. Participating residents will be required to leave the house during the time period of indoor sample collection.

Each home sampled will have two 4-hour samples collected to represent indoor air levels during two categories of activity: passive and active.

Period 1 (Passive Behaviors)
In this 4-hour interval, the EPA contractor will engage in minimal physical activity. Movement will be restricted to walking between rooms and sitting on upholstered chairs and/or cushions. While seated, the EPA contractor may read, watch television, or complete required paperwork.

Period 2 (Active Behaviors)
In this 4-hour interval, the contractor will engage in a standardized sequence ("script") of "active" behaviors, as detailed in Attachment B. This script is intended to capture a wide range of different activities that residents may engage in during normal living conditions. This includes things such as walking between rooms, sitting down on chairs and couches, simulated play with children or pets, sweeping, vacuuming, and dusting.

In order to ensure that each 4-hour sample is spatially representative of the home, each sample shall be collected from multiple rooms on all floors of the home. Therefore, prior to beginning sample collection, each residential structure will be assessed to determine the number of rooms on each regularly occupied floor of the main structure where sampling will be conducted. This

information will also be captured in the ABS investigation form included in Attachment A. The total sampling time for each period (passive and active) will be divided evenly among the total number of rooms in which routine living activities occur. For example, if the home is comprised of a basement that contains 2 rooms (e.g., 1 bedroom, 1 home gym) and a ground floor that contains 6 rooms (e.g., living room, 1 bathroom, kitchen, and 3 bedrooms), the total time of the active and passive sampling periods (4 hours each) would be divided evenly among the 8 rooms (240 minutes / 8 rooms = 30 minutes per room).

Comment [b5]: We had a discussion on whether time should be partitioned on a by-room basis or should be based on area of the rooms. I think by-room is best, but can't remember if we decided otherwise.

Comment [R6]: I am ok with a "by room" approach.

If it is necessary to relieve a participant from an activity, a relief (backup) participant will be properly suited in time to make the exchange. When the relief participant is ready, the activity participant will stop, remove the backpack or belt, pass it to the relief participant, and assist the relief participant with donning and adjusting the backpack or belt. The exchange is anticipated to take less than 60 seconds, so the sampling pumps and event time clock will not be halted during the exchange. If the exchange requires more than 60 seconds, the pump and event clock will be stopped until activity is re-initiated.

Depending on what is most convenient for the resident, sampling will either occur over one 8-hour time interval, divided into two sub-periods of 4-hours each, or else will occur by collecting two 4-hour samples on two sequential days. If both samples are collected on one day, the passive activity sample will be collected in the morning, and the active sample will be collected in the afternoon to minimize the likelihood of cross-contamination between activity periods. If samples are collected on two sequential days, the order of collection may be random. That is, if the active phase is conducted in the morning of the first day at House #1 then the passive phase of sampling will be conducted at House #1 in the afternoon on the second day.

Two personal air samples will be collected during each 4 hour sub-period, one to serve as a backup in case the other fails or is damaged or lost. Both monitors will draw air at a flow rate of 10 liters per minute (L/min) through a 25 mm MCE filter with 0.8 um pore size. The flow rates for sample collection should be 10 and 3.5 liters per minute resulting in target volumes of 2,400 and 840 liters, respectively. These flow rates were chosen for this sampling event in order to maximize the volume of air collected which in turn helps achieve the analytical sensitivities required for risk assessment evaluations. For all asbestos sampling, an asbestos sampling train consisting of 0.8-micron (µm), 25-millimeter (mm) mixed cellulose ester (MCE) filter connected to a sampling pump will be used. The top cover from the cowl extension on the sampling cassette shall be removed ("open-face") and the cassette oriented face down.

Both the high volume and low volume samples will be submitted to the laboratory for analysis. If the higher volume sample is not readable by transmission electron microscopy (TEM) after a direct preparation method, either the lower flow sample may be evaluated for analysis by direct

preparation, or the higher flow sample may be used by applying an indirect sample preparation technique. *The laboratory must consult with EPA in order to select which is the most appropriate approach to follow.*

Indoor air sampling will be conducted in accordance with SOP EPA-LIBBY-01 (see Attachment A), Revision 1, except where modified in this SAP.

Pump Fault and Flow-Rate Error Procedures

Pump flow rates will be verified at 60 minute intervals or when participants are relieved from an activity by a backup participant, whichever occurs sooner. If at anytime the observed flow rates are ±10% of the target rate, the sampling pump should be re-calibrated. If at any time an air sampling pump is found to have faulted or the observed flow rates are 30% below or 50% above the target rate, Figure 4-2 should be consulted to determine the next appropriate action. The time elapsed from the start of the activity until the fault/flow observation will be used to determine the appropriate action according to Figure 4-2.

To calculate the percentage of an observed flow to the target flow, the following formula is used:

$$X\% = \frac{Observed\ Flow\ Rate\ (L/min)}{Target\ Flow\ Rate\ (L/min)} \cdot 100$$

Figure 4-2 Procedures for Pump Fault and Flow-Rate Errors

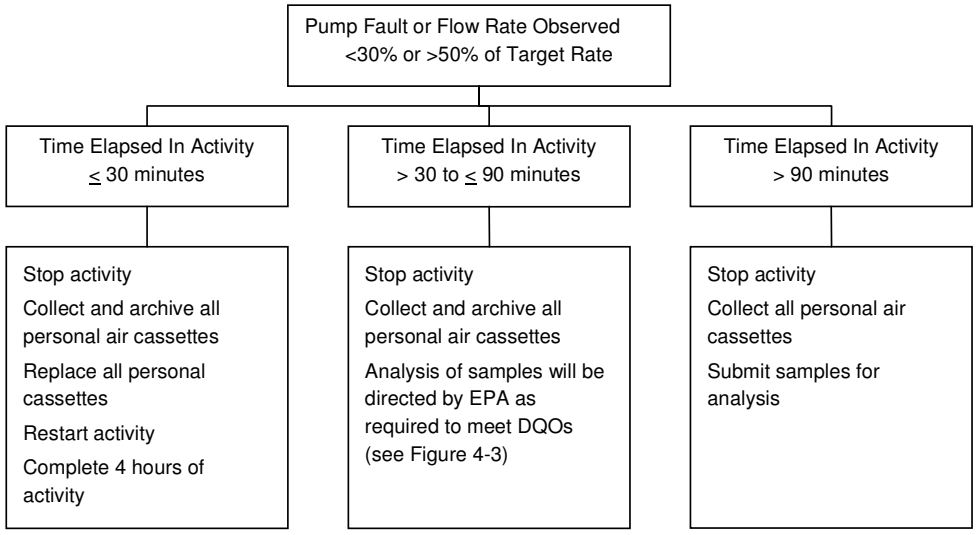
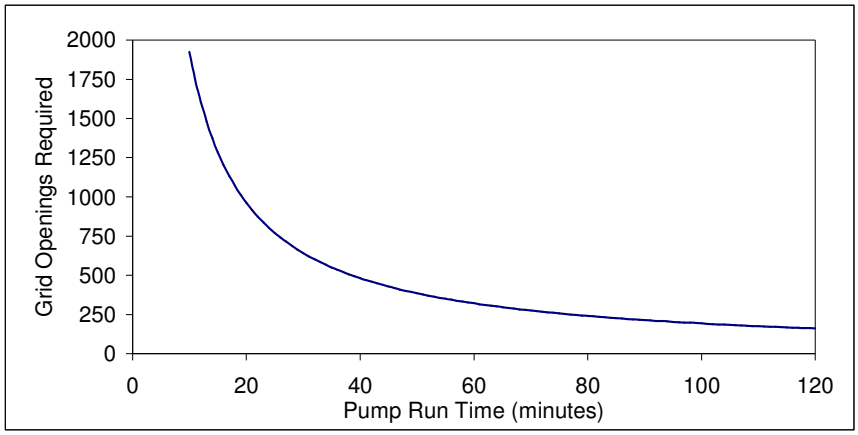


Figure 4-3 (below) illustrates the number of grid openings that will require analysis to achieve the target sensitivity (0.0002 cc^{-1}) when the flow is 10 L/min and there is a pump fault before two hours have elapsed.

Figure 4-3. Effect of Pump Time on Grid Openings Required



4.2.2 Indoor Dust Sampling

At each property included in this effort, one composite indoor dust sample will be collected using the microvacuum method described in [add reference to revised dust SOP]. These samples will be collected from the same rooms where the EPA contractor performs the "active" and "passive" activities described above. Note that each sample may be collected on multiple cassettes if filter overloading and reduced pump rate is detected. Dust collection shall occur before the start of the first activity period.

Comment [R7]: Troy dust SOP.

4.2.3 Outdoor Soil Sampling

At each property included in this effort, one 30-point composite soil sample will be collected to represent all SUAs. All 30 sub-samples will be approximately equal in size (mass), collected in accordance with the Site-Specific Standard Operating Procedures for Soil Sample Collection (CDM-Libby-05, Revision 2).

At each property included in this effort, a second composite soil sample will be collected to represent all NSUAs. Each NSUA composite sample will contain 30 sub-samples, distributed approximately evenly throughout the NSUA portions of the property.

In order to ensure that sufficient sample is available for potential future investigations, the mass of each composite sample must be no less than 2.0 kg.

In addition, a sketch of the outdoor yard will be prepared that indicates the approximate locations and size of each SUA, the approximate location and level of any visible vermiculite in the yard, and the approximate locations of all sub-samples used to represent SUAs and NSUAs. This should be done in accord with the Site-Specific Standard Operating Procedure for Semi-Quantitative Visual Estimation of Vermiculite in Soil (CDM-Libby-06, Revision 1) with the following modifications:

- All areas of the property will be divided into zones and inspected for visual vermiculite regardless of previous excavations or presence of LA
- Interior surfaces (e.g., crawlspace, shed floor) will not be inspected for visual vermiculite

When possible, outdoor soil sampling and observations should occur close to the time that the first round of indoor air samples are collected. However, when necessary, the outdoor soil data may collected at a different time, since it is not expected that LA levels in outdoor soil vary substantially over time. Sampling will only be conducted in association with the first round of indoor sampling, and will not be required for subsequent sampling rounds.

4.2.4 MET Station Data

During days when indoor ABS activities are occurring, meteorological (MET) weather station data will be downloaded from the local National Oceanic Atmospheric Administration (NOAA) station, LBBM8. The following parameters are recorded hourly at this station: temperature (°F), dew point (°F), relative humidity (%), wind speed (mph), wind gust (mph), wind direction, solar radiation (watts/m^2 per hour), and precipitation (inches). Copies of all MET station data will be provided to EPA and SRC within one week of collection. Electronic copies have been determined to be suitable and will be placed in the project e-room.

4.3 General Processes

4.3.1 Equipment Decontamination

Decontamination of air sampling pumps and soil sampling equipment will be conducted as described in Section 3.1.1.2 of the SWQAPP (CDM 2007a).

4.3.2 Sample Labeling and Identification

Sample index identification numbers will identify the samples collected during this study by having the following format:

IN-#####

where:

IN = Interior Activity Based Sampling
= a sequential five digit number

4.3.3 Videotape Documentation

A videotape will be prepared to document a representative example of each activity including any special conditions or circumstances that arose during the activity.

4.3.4 Field Logbooks

Field logbooks will be completed and managed as described in Section 3.2.4 of the SWQAPP (CDM 2007a). CDM SOP 4-1, Field Logbook Content and Control including project-specific modification is provided in Attachment A. Copies of all logbook entries will be provided to EPA and SRC within one week of collection. Electronic copies are suitable and will be placed in the project e-room within one week after the completion of each sampling event.

4.3.5 FSDSs

Field Sample Data Sheets (FSDSs) will be completed and managed as described in Section 3.2.5 of the SWQAPP (CDM 2007a). Attachment C contains copies of the specific FSDSs that will be used to record information for samples collected during the activities described in this SAP. Copies of FSDSs will be provided to EPA and SRC within one week of collection. Electronic copies are suitable and will be placed in the project e-room within one week after the completion of each sampling event.

4.3.6 Photographic Documentation

Photographs will be collected, documented, and managed as described in Section 3.2.7 of the SWQAPP (CDM 2007a). CDM SOP 4-2, Photographic Documentation of Field Activities including project-specific modification is provided in Attachment A. Photographs will be used to document areas where indoor activities are conducted. File names will be in the format:

last name of property owner_address_IABS_date

where:

IABS = Interior Activity Based Sampling
Date = MM_DD_YY

4.3.7 GPS Point Collection

Global Positioning System (GPS) location coordinates will be collected soil samples as described in Section 3.2.8 of the SWQAPP (CDM 2007a) and in accordance with CDM-LIBBY-09, provided in Attachment A. Coordinates for buildings will be collected only if the building does not already have an assigned GPS location.

4.3.8 Field Equipment Maintenance

Air sampling pump calibrations will be conducted and documented as described in Section 3.1.1.2 of the SWQAPP (CDM 2007a). Field equipment maintenance will be conducted and documented as described in Section 3.2.9 of the SWQAPP (CDM 2007a). CDM SOP 5-1, Control of Measurement and Test Equipment, is provided in Attachment A.

4.3.9 Handling Investigation Derived Waste (IDW)

Investigation derived waste (IDW) will be managed as described in Section 3.2.10 of the SWQAPP (CDM 2007a). CDM SOP 2-2, Guide to Handling of IDW, including a project-specific modification is provided in Attachment A.

4.3.10 Field Sample Custody and Documentation

Field Sample Custody and documentation will follow the requirements described in Section 3.2.11 of the SWQAPP (CDM 2007a). CDM SOP 1-2, Sample Custody, including a project-specific modification is provided in Attachment A. Copies of all COCs will be provided to EPA and SRC within one week of collection. Electronic copies are suitable and will be placed in the project e-room within one week after the completion of each sampling event.

4.3.11 Sample Packaging and Shipping

Sample packaging and shipping will follow the requirements described in Section 3.2.12 of the SWQAPP (CDM 2007a). CDM SOP 2-1, Packaging and Shipping of Environmental Samples, including a project-specific modification is provided in Attachment A.

4.3.12 Modification Forms

All deviations will be documented and recorded according to the requirements described in Section 3.2.13 of the SWQAPP (CDM 2007a).

4.3.13 Field Surveillances and Audits

Field surveillances and audits will be conducted according to the requirements described in Section 3.2.14 of the SWQAPP (CDM 2007a).

4.4 QA/QC Activities

The quality assurance (QA)/quality control (QC) actions required for each process described in this SAP will follow the requirements described in the SWQAPP (CDM 2007a).

4.4.1 Collection of QA/QC Field Samples

QA/QC samples will be collected according to the procedures described in the SWQAPP (CDM 2007a). All QA/QC field samples will be collected at the frequencies described in the SWQAPP with the exception of the frequency of drying blanks and field blanks for air samples. It is expected that drying air sample cassettes will not be required for this activity. One field blank for dust samples and one field blank for air samples will be collected at each property per day when activities are conducted. All field blanks collected as part of this program will be analyzed by counting a number of grid openings that is approximately equal to the number of grid openings that are analyzed for field samples. Table 4-1 summarizes the QA/QC sample collection and analysis frequencies for the indoor ABS investigation.

5.0 LABORATORY ANALYSIS AND REQUIREMENTS

All laboratories that analyze samples collected as part of this project must participate in and have satisfied the certification requirements in the last two proficiency examinations from the National Institute of Standards and Technology/National Voluntary Laboratory Accreditation Program (NVLAP). The laboratory must also analyze performance evaluation samples when requested. These analyses must be performed before any samples are submitted to the laboratory to confirm the laboratory's capabilities and may be subsequently submitted at regular intervals. In addition, the laboratory must participate in the laboratory training program developed by the Libby laboratory team.

5.1 Analytical Methods

5.1.1 Air and Dust

All indoor air and indoor dust samples will be submitted to a subcontracted laboratory for analysis using the International Organization for Standardization (ISO) TEM method 10312, also known as ISO 10312:1995(E) (CDM 2003a) with project specific modifications LB-000016, LB-000019, LB-000028, LB-000029, LB-000029a, LB-000030, LB-000053, and LB-000066b (CDM 2003b). All asbestos structures (including not only Libby amphibole but all other asbestos types as well) that have appropriate diffraction patterns and EDS spectra, and having length greater than or equal to 0.5 um and an aspect ratio $\geq$ 3:1, will be recorded on the Libby site-specific laboratory data sheets and electronic deliverables.

As described in the latest version of laboratory modification LB-000029, the frequency for laboratory-based QC samples for TEM analysis is:

- Lab blank = 4%
- Recount same = 1%
- Recount different = 2.5%
- Re-preparation = 1%
- Verified analysis = 1%
- Inter-laboratory = 0.5%

5.1.2 Soil

All soil samples collected as part of this effort will be analyzed by polarized light microscopy (PLM) in accord with SOPs SRC-LIBBY-01 (Revision 2) and SRC-LIBBY-03 (Revision 2).

5.1.3 Sample Archival

All air samples will be distributed to a project laboratory for analysis. Both the high volume and low volume samples will be sent to the same laboratory. Once analyzed, all samples will be stored (archived) at the laboratory under COC until further notice.

Aliquots of soil not sent for analysis will be archived at the Soil preparation Laboratory in accord with standard practice, as detailed in the latest version of the Close Support Facility Soil Preparation Plan.

5.2 Analytical Sensitivity for TEM Analyses

5.2.1 Indoor Air Samples

As discussed in Section 3.1, the target analytical sensitivity for indoor air samples is 0.0002 cc^{-1}. In the event of sample loading or other issues where a sensitivity of 0.0002cc^{-1} can not be achieved, the laboratory may report a sample result with a higher (poorer) sensitivity only after consultation with EPA project personnel and preparation of a temporary modification form.

5.2.2 Indoor Dust Samples

The target analytical sensitivity for indoor dust samples collected as part of this effort will be 20 per cm^2. This level is sufficient that it will allow reasonable quantification of dust concentration across the wide range of values (from <20 up to a maximum of 5,000 s/cm^2) expected to exist in the various residences.

5.3 Holding Times

No preservation requirements or holding times are established for air samples collected for asbestos analysis.

5.4 Laboratory Custody Procedures and Documentation

Laboratory custody procedures and documentation will be completed as required by the specifications detailed in Section 4.5 of the SWQAPP (CDM 2007a).

5.5 Documentation and Records

Laboratory documentation and records will be completed as required by the specifications detailed in Section 4.7 of the SWQAPP (CDM 2007a).

5.6 Data Management

Sample results data will be delivered to the Volpe Center and CDM's Cambridge office both in hard copy and as an electronic data deliverable (EDD). Electronic copies of all project deliverables, including graphics, will be filed by project number. Electronic files will be routinely backed up and archived.

All results, field data sheet information, and survey forms will be maintained in the Libby project database managed by the Volpe Center under the oversight of the Volpe Center database management team.

6.0 ASSESSMENT AND OVERSIGHT

Assessments and oversight reports to management are necessary to ensure that procedures are followed as required and that deviations from procedures are documented. These reports also serve to keep management current on field activities. Assessment, oversight reports, and response actions are discussed below.

6.1 Assessments

Performance assessments are quantitative checks on the quality of a measurement system and are appropriate to analytical work. Performance assessments for the laboratories may be accomplished by submitting reference material as blind reference (or performance evaluation) samples. These assessment samples have known concentrations of LA that are submitted to the laboratories blind (i.e., without informing the laboratories that they are performance evaluation samples). Laboratory audits may be conducted upon request from the EPA Team leader (TL) or Volpe Center project manager (PM).

System assessments are qualitative reviews of different aspects of project work to check on the use of appropriate QC measures and the functioning of the QA system. Project assessments will be performed under the direction of the QA managers, who report directly to the CDM president. Quality Procedure 6.2, as defined in the CDM QA Manual (CDM 2007b), defines CDM 's corporate assessments, procedures, and requirements. Due to the amount of sampling and the duration of the Libby project, both a field audit and an office audit are scheduled for the Site annually.

6.2 Response Actions

Response actions will be implemented on a case-by-case basis to correct quality problems. Minor response actions taken in the field to immediately correct a quality problem will be documented in the applicable field logbook and a verbal report will be provided to the CDM PM. For verbal reports, the CDM PM will complete a communication log to document the response actions were relayed to him/her. Major response actions taken in the field will be approved by the CDM PM, the EPA RPM, and Volpe PM prior to implementation of the change. Major response actions are those that may affect the quality or objective of the investigation. Quality problems that cannot be corrected quickly through routine procedures may require implementation of a corrective action request (CAR) form.

All formal response actions will be submitted to either CDM 's QA manager and/or project QA coordinator for review and issuance. CDM 's PM or local QA coordinator will notify the QA

manager when quality problems arise that may require a formal response action. CAR forms will be completed according to Quality Procedure 8.1 of the CDM QA Manual (CDM 2007b). In addition, when modifications to this specific SAP are required, either for field or laboratory activities, a Libby Asbestos Project Record of Modification Form (Attachment D) must be completed.

6.3 Reports to Management

QA reports will be provided to management whenever quality problems are encountered. Field staff will note any quality problems on field data sheets, or in field logbooks. CDM 's PM will inform the project QA coordinator upon encountering quality issues that cannot be immediately corrected. Weekly reports and change request forms are not required for this work assignment. Monthly QA reports will be submitted to CDM 's QA manager by the project QA coordinator.

Topics to be summarized regularly may include but not be limited to:

- Document technical and QA reviews that have been conducted
- Activities and general program status
- Project meetings
- Corrective action activities
- Any unresolved problem
- Any significant QA/QC problems not included above

7.0 DATA VALIDATION AND USABILITY

Laboratory results will be reviewed for compliance with project objectives. Data validation and evaluation are discussed in Sections 7.1 and 7.2, respectively.

7.1 Data Review, Validation, and Verification Requirements

Data review, validation, and verification will be performed for important investigative samples as described in the SWQAPP. Data validation, review, and verifications must be performed on sample results before distribution to the public for review. Requirements for the frequency of data review are initially set at 10%. This initial rate may be revised as initial samples are analyzed and results evaluated.

Data validation consists of examining the sample data package(s) against pre-determined standardized requirements. The validator may examine, as appropriate, the reported results, QC summaries, case narratives, COC information, raw data, initial and continuing instrument calibration, and other reported information to determine the accuracy and completeness of the data package. During this process, the validator will verify that the analytical methodologies were followed and QC requirements were met. The validator may recalculate selected analytical results to verify the accuracy of the reported information. Analytical results will then be qualified as necessary.

Data verification includes checking that results have been transferred correctly from laboratory data printouts to the laboratory report and to the EDD. Data verification for this project is primarily performed as a function of built-in quality control checks in the Libby project database when data is uploaded. However, the sample coordinator will notify the laboratories and the project database manager (Mr. Mark Raney, Volpe Center) of any discrepancies found during data usage.

7.2 Reconciliation with Data Quality Objectives

Once data has been generated, CDM evaluates data to determine if DQOs were achieved. This achievement will be discussed in the measurement report, including the data and any deviations to this SAP. Sample data will be maintained in the project database (Libby2). Laboratory QC sample data will be stored in hard copy (in the project files) and in Libby2.

8.0 PROJECT SCHEDULE

It is anticipated that initial outdoor assessments to determine locations for indoor ABS sample collection will begin in May 2007. The first event of indoor ABS sampling is currently planned to be conducted from June 2007 to August 2007. It is anticipated that results from this round of sampling will be available for tabulation and release for public review in October 2007.

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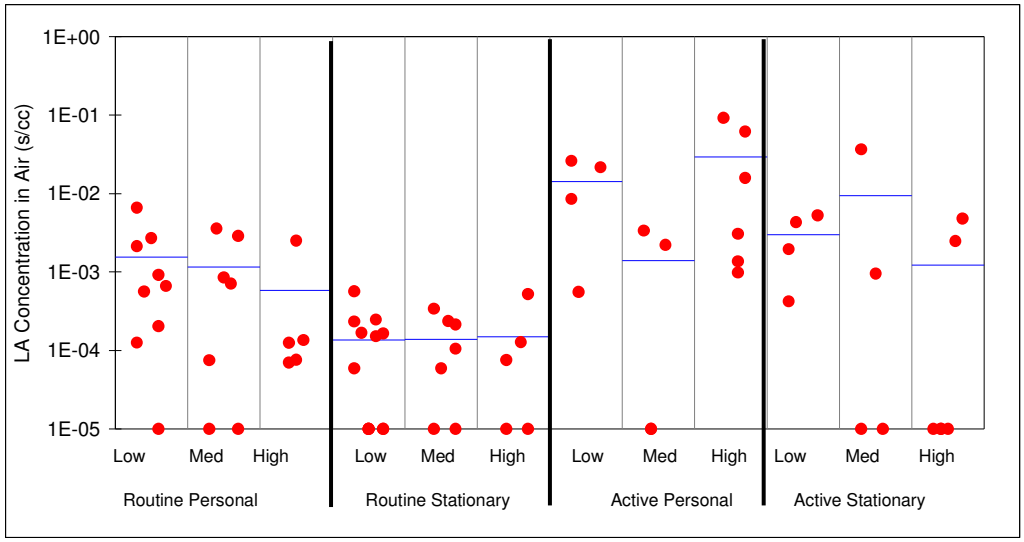
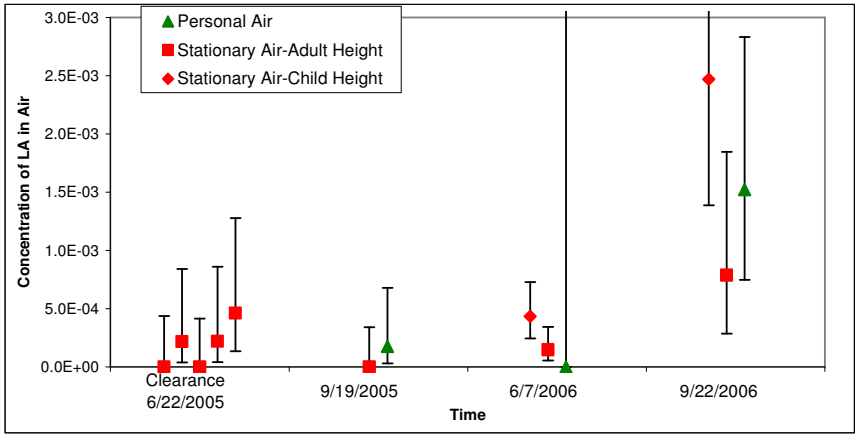
FIGURE 2-1
AVAILABLE DATA ON INDOOR AIR LEVELS
AT PRE-REMEDIATION HOMES IN LIBBY



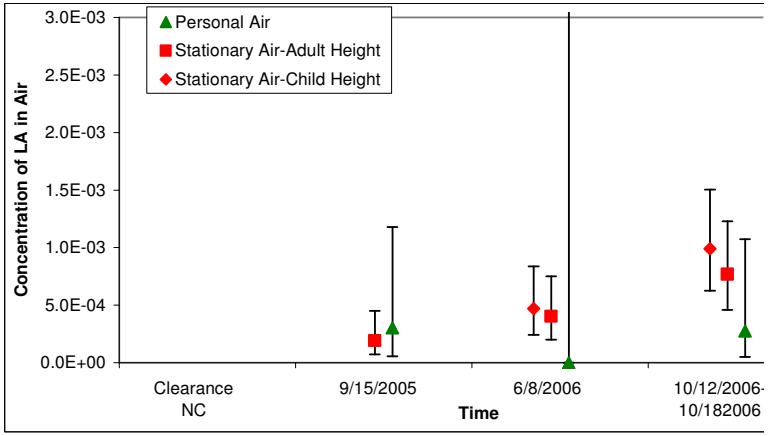
Dust Rank	Statistic	Dust (s/cm^2)	Rountine Air (s/cc)		Active Air (s/cc)	
			Personal	Stationary	Personal	Stationary
All	N	32	21	24	14	14
	Mean	427	1.19E-03	1.40E-04	1.70E-02	4.06E-03
	Stdev	1479	1.68E-03	1.59E-04	2.75E-02	9.55E-03
	UCL	1567	2.36E-03	4.62E-04	5.21E-02	2.29E-02
Low	N	15	9	12	4	4
	Mean	3	1.55E-03	1.37E-04	1.42E-02	2.99E-03
	Stdev	6	2.12E-03	1.64E-04	1.18E-02	2.20E-03
	UCL	9	4.42E-03	5.67E-04	2.60E-02	5.26E-03
Med	N	10	7	7	4	4
	Mean	64	1.16E-03	1.40E-04	1.40E-03	9.38E-03
	Stdev	39	1.47E-03	1.27E-04	1.67E-03	1.81E-02
	UCL	86	3.58E-03	2.33E-04	3.36E-03	3.66E-02
High	N	7	5	5	6	6
	Mean	1855	5.84E-04	1.50E-04	2.92E-02	1.22E-03
	Stdev	2872	1.08E-03	2.15E-04	3.87E-02	2.02E-03
	UCL	5310	2.51E-03	4.81E-03	6.11E-02	4.81E-03

Note: Some data have not yet been fully validated and some data points may be revised in the future.

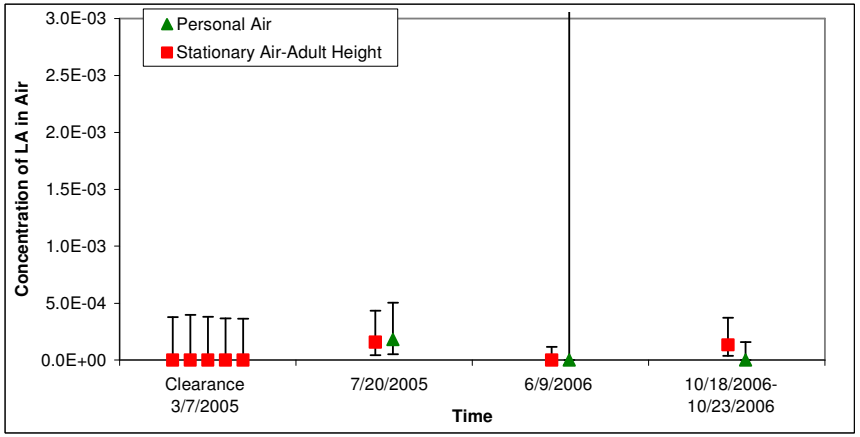
FIGURE 2-2
INDOOR AIR RESULTS FOR POST CLEANUP PROPERTIES

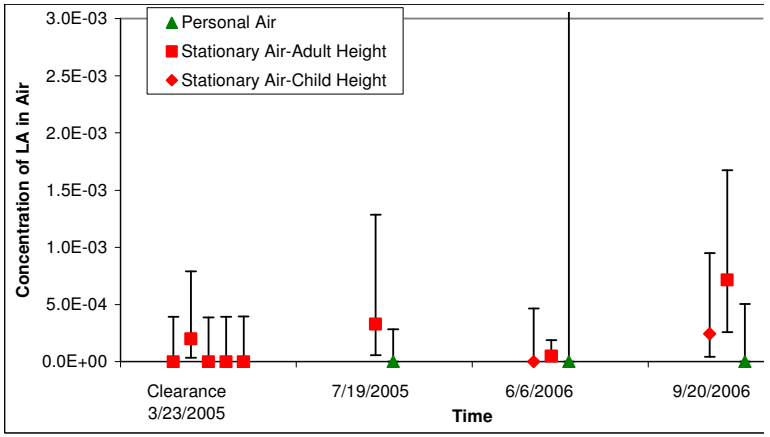


411 E. 10th St.



709 E. 5th St.

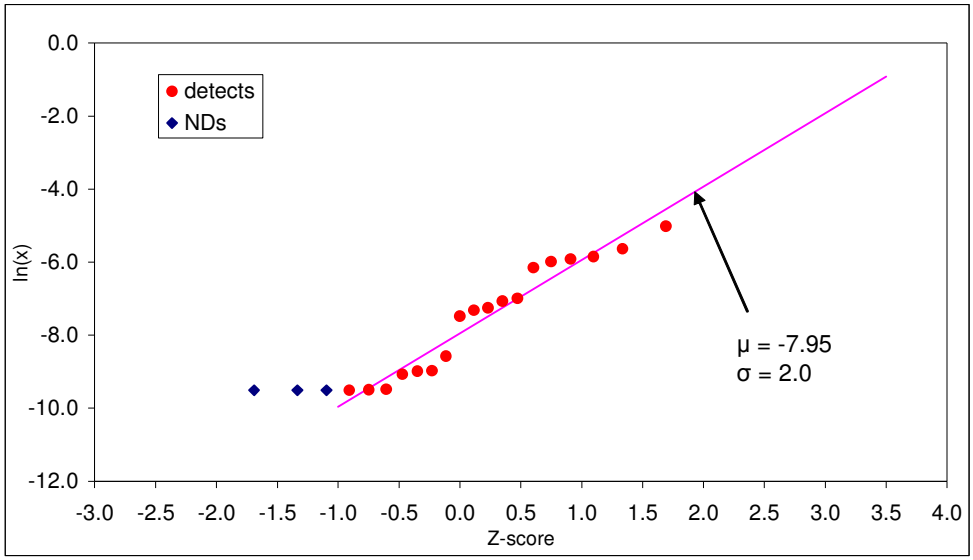




Note: some data points have not been fully validated, and some data may be revised in the future.

FIGURE 3-1
LOG-PROBABILITY PLOTS OF PERSONAL INDOOR AIR SAMPLES

Panel A: Routine Activity



Panel B: Active Cleaning

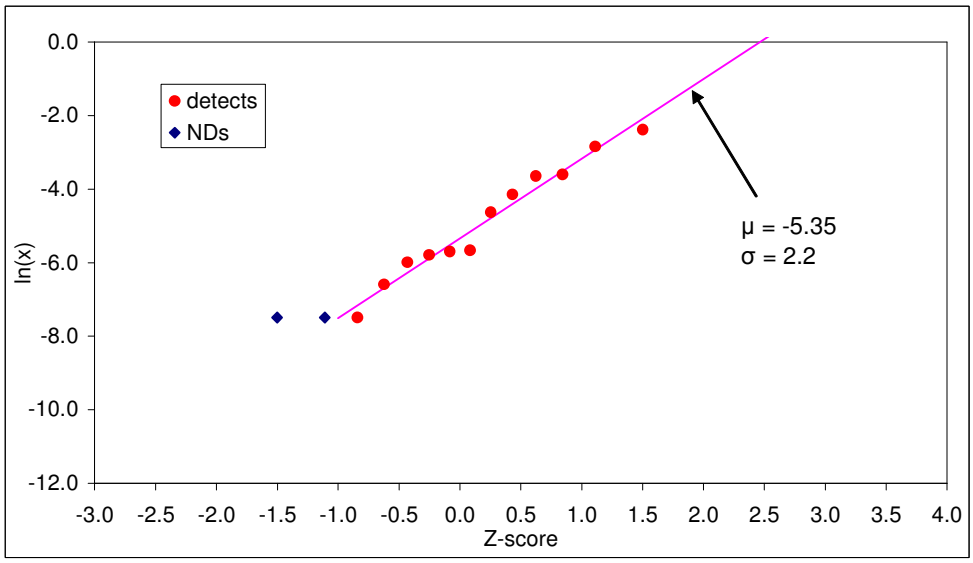


FIGURE 3-2
EXAMPLE UNCERTAINTY IN THE MEAN
OF A LOGNORMAL DATA SET WITH Σ = 2.0

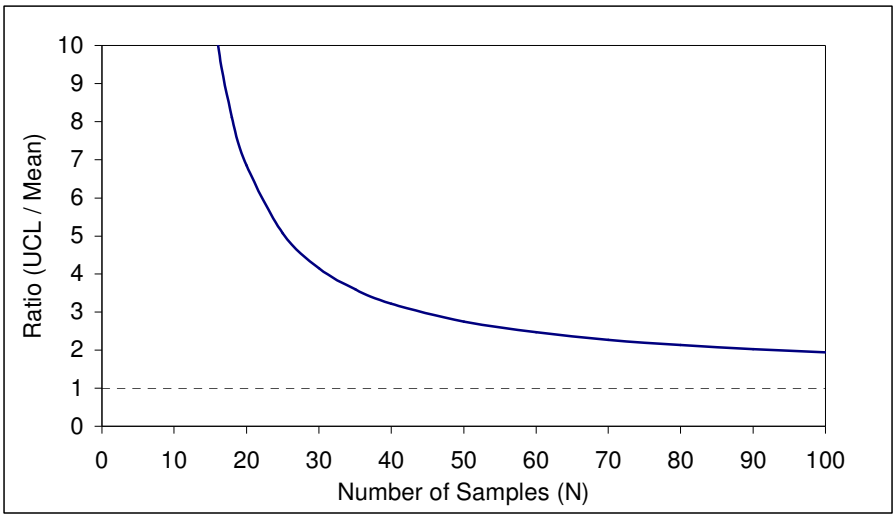
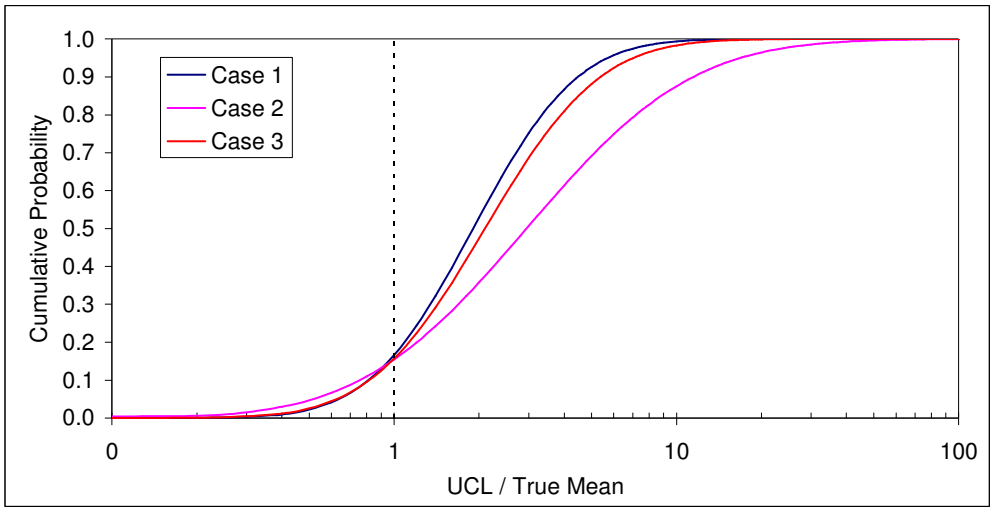


FIGURE 3-3
EFFECT OF DECREASING SAMPLE NUMBER OR
INCREASING ANALYTICAL SENSITIVITY ON DATA QUALITY

Panel A: CDFs



Pandl B: PDFs

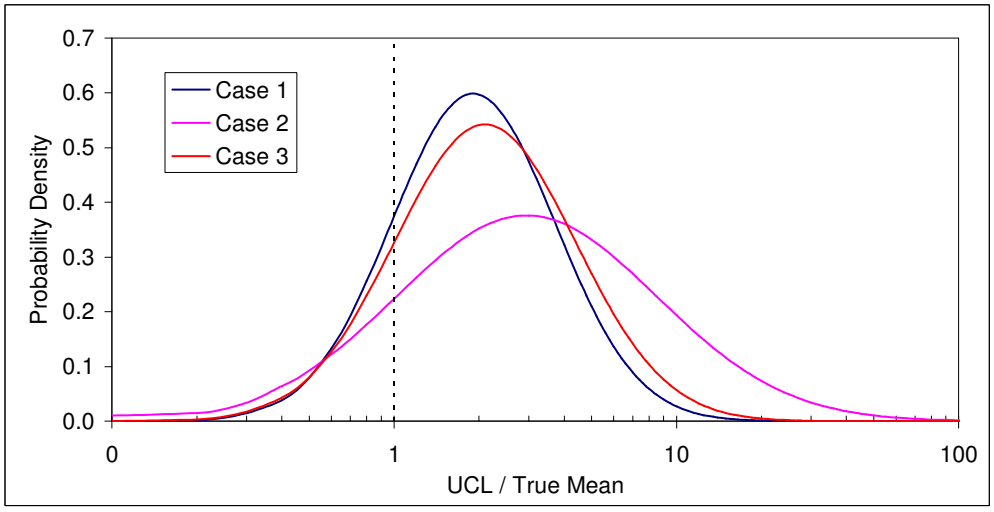


TABLE 4-1
SUMMARY OF FIELD QC SAMPLES BY MEDIUM

Media	Sample Type	Minimum Collection Frequency		Minimum Analysis Frequency	Acceptance Criteria	Acceptance Criteria Failure Action
Air	Lot Blank	1 per 50 cassettes	2%	1 per 50 cassettes	ND for all asbestos	Rejection of all cassettes in lot
	Field Blank	1 per property per day		10% of total collected per week	ND for all asbestos fibers	Analysis of additional field blanks to determine source of potential cross-contamination, qualification of sample results, evaluation of field sample handling procedures
	Co-located	1 per 20 samples	5%	100%	>90% RPD	Evaluation of sample collection techniques
Dust	Lot Blank	1 per 50 cassettes	2%	1 per 50 cassettes	ND for all asbestos	Rejection of all cassettes in lot
	Field Blank	1 per property per day		10% of total collected per week	ND for all asbestos fibers	Analysis of additional field blanks to determine source of potential cross-contamination, qualification of sample results, evaluation of field sample handling procedures
Soil	Field Duplicate	1 per 20 samples	5%	100%	>90% RPD	Evaluation of sample collection techniques
	Equipment Blank	1 per team per week		1 per week	ND for all asbestos fibers	Evaluation of sample collection techniques, possible qualification of sample results during validation/evaluation

Notes: QC - quality control; ND - nondetect; RPD - relative percent difference; COC - chain of custody